Carl Zeiss Jena GmbH
Attorney's File: PAT 1250/192-PCT

February 27, 2004

Claims

1. A projection device comprising a reflective light modulator (1) for generating an image, said light modulator comprising a plurality of independently controllable pixels (P1, P2, P3) which are arranged in one image plane and can be respectively put in at least one of a first and a second state and which form an image-generating region, said projection device further comprising a light source unit (3) for illuminating the pixels (P1, P2, P3) and comprising projection optics (6) which include first and second partial optics (7, 8), said projection optics having an optical axis (OA), wherein the light source unit (3), during operation of the projection device, emits an illumination ray bundle (9) for illumination of the pixels (P1-P3), said illumination ray bundle (9) passing through the first partial optics (7), which contain at least a first lens (15; 17, 18, 19), and then impinging on the pixels (P1-P3), wherein the light reflected by the pixels (P1-P3) being in the first state passes, as a projection ray bundle (10) for projection of the image onto a projection surface (11), through the first partial optics (7) and then through the second partial optics (8), and wherein, upon passage of the illumination ray bundle (9) through the first partial optics (7), a respective reflection ray bundle (R1, R2, R3, R4, R5, R6, R7, R8) is generated by the first partial optics (7) at each optical boundary surface (W1, W2, W3, W4, W5, W6) of each lens (15; 17-19) of the first partial optics (7), said reflection ray bundle propagating up to the second partial optics (8) without further reflection at the optical boundary surfaces (W1-W6), said projection device being **characterized in that** each optical boundary surface (W1-W6) of each lens (15; 17-19) of the first partial optics (7) is curved and/or arranged such that, in a reference plane in which the optical axis (OA) of the projection optics (6) is located and which is divided by the optical axis (OA) into upper and lower half-planes (H1, H2), each reflection ray bundle (R1, R2; R3-R8) exiting the first partial optics (7) proceeds completely either into the first or into the second half-plane (H1, H2), in order to prevent the reflection ray bundles (R1, R2; R3-R8) from being projected onto the projection surface (11).

2. The projection device as claimed in Claim 1, characterized in that each optical boundary surface (W1-W6) of each lens (15; 17-19) is curved and/or arranged such that all reflection ray bundles exiting the first partial optics (7) proceed into the same half-plane (H1).

3. The projection device as claimed in Claim 2, characterized in that the light source unit (3) is arranged such that the illumination ray bundle (9) in the reference plane is directed onto the first partial optics (7) from the other of the two half-planes (H2).

4. The projection device as claimed in any one of the above Claims, characterized in that the reflection ray bundles (R1-R8) are respectively not coupled or only partially coupled into the second partial optics (8) and are blocked out therein no later than the aperture stop of the projection optics (6).

5. The projection device as claimed in any one of the above Claims, characterized in that a deflecting element for folding the beam path is arranged in the projection optics (6).

6. The projection device as claimed in any one of the above Claims, characterized in that, in total, the first partial optics (7) have positive refractive power.

7. The projection device as claimed in any one of the above Claims, characterized in that the optical axis (OA) of the projection optics (6), when viewing the image-generating area from above, impinges on the image-generating region, preferably approximately in the middle.

8. The projection device as claimed in Claim 7, characterized in that the optical axis (OA) vertically impinges on the image-generating region.

9. The projection device as claimed in any one of the above Claims, characterized in that the at least first lens (15) is offset in the reference plane transverse to the optical axis (OA).

10. The projection device as claimed in any one of the above Claims, characterized in that the at least first lens (15) in the reference plane is tilted by a first angle relative to the optical axis (OA).

11. The projection device as claimed in Claim 10, characterized in that the image plane is tilted by a second angle relative to the optical axis (OA), said first and said second angles preferably being equal in amount.

12. The projection device as claimed in any one of Claims 9 to 11, characterized in that the imaging error of the projection optics (6) caused by offset and/or tilting of the first lens is compensated for at least in part by tilting at least one lens of the second partial optics and/or by at least one wedge or at least one tilted plane plate.

13. The projection device as claimed in any one of the above Claims, characterized in that the first partial optics (7) comprise at least two lenses, which are offset and/or tilted relative to each other such that the imaging errors of the at least two lenses caused by said offset and/or tilting compensate each other at least in part.

14. The projection device as claimed in any one of the above Claims, characterized in that the first lens is a meniscus lens (17-19) having positive refractive power, with the convex side of the meniscus lens (17-19) facing the pixels (P1-P2).

15. The projection device as claimed in any one of the above Claims, characterized in that the first lens (15; 17-19) is made of a material having a refractive index of at least 1.7.

16. The projection device as claimed in any one of the above Claims, characterized in that, in the reference plane, a partial illumination ray bundle (B1, B2, B3), by which a pixel (P1-P3) is illuminated, and a partial projection ray bundle (S1, S2, S3), which comes from the pixel (P1-P3) being in the first state, cover a non-contiguous angular range.

17. The projection device as claimed in any one of the above Claims, characterized in that the light modulator (1) comprises a tilting mirror matrix and the reference plane is perpendicular to the tilting axes of the tilting mirrors.

18. The projection device as claimed in any one of the above Claims, characterized in that the projection device is provided as a back projection device comprising a projection surface which is provided as a back projection screen.

19. The projection device as claimed in any one of the above Claims, characterized in that all lenses of the projection optics (6) are located on a common optical axis (OA).

20. The projection device as claimed in any one of the above Claims, characterized in that the projection optics (6) are provided as substantially centered and rotation-symmetrical optics, which are preferably substantially telecentric.

21. The projection device as claimed in any one of the above Claims, characterized in that the position of the second partial optics (8) or of part thereof is variable in the direction of the optical axis (OA).

22. The projection device as claimed in any one of the above Claims, characterized in that the projection optics (6) comprise a shading stop (16) having a rotation-symmetrical stop aperture, in a stop plane which is conjugated counter to the image plane.

23. The projection device as claimed in Claim 22, characterized in that part of the stop aperture is shaded by an additional stop element.